DOCUMENT RESUME

ED 216 933 SE 038 137

AUTHOR Stoever, Edward, C., Jr.
TITLE Plotting the Shape of the Ocean Floor. Crustal Evolution Education Project. Teacher's Guide [and] Student Investigation.
INSTITUTION National Association of Geology Teachers.
SPONS AGENCY National Science Foundation, Washington, D.C.
REPORT NO CEEP-MOD-NY11-3-1; ISBN-0-89873-044-9; ISBN-0-89873-045-7
PUB DATE 79
GRANT SED-75-20151; SED-77-08539; SED-78-25104
NOTE 29p.
AVAILABLE FROM Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, NY 14603 (or P.O. Box 1749, Monterey, CA 93940.)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Earth Science; Geology; Instructional Materials; *Oceanography; *Science Activities; *Science Course Improvement Projects; *Science Curriculum; Science Education; Science Instruction; Secondary Education; *Secondary School Science; Seismology; Teaching Guides; Teaching Methods; Topography
IDENTIFIERS *Crustal Evolution Education Project; Earthquakes; National Science Foundation; *Plate Tectonics

ABSTRACT

Crustal Evolution Education Project (CEEP) modules were designed to: (1) provide students with the methods and results of continuing investigations into the composition, history, and processes of the earth's crust and the application of this knowledge to man's activities and (2) to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift, and plate tectonics. Each module consists of two booklets: a teacher's guide and student investigation. The teacher's guide contains all of the information present in the student investigation booklet as well as: (1) a general introduction; (2) prerequisite student background; (3) objectives; (4) list of required materials; (5) background information; (6) suggested approach; (7) procedure, recommending two-three 45-minute class periods; (8) summary questions (with answers); (9) extension activities; and (10) list of references. In this module students draw a profile of the sea floor using bathymetric data, identify which topographic elements are similar on many bathymetric profiles across a portion of the North Atlantic sea floor, describe relationships between sea-floor topography and earthquake epicenter locations, compare/contrast bathymetric profile features on a map, and compare distribution of earthquake epicenters on bathymetric profiles with those seen on a World Seismocity Map. (Author/JN)

CEEP™

CRUSTAL
EVOLUTION
EDUCATION
PROJECT

Plotting The Shape Of The Ocean Floor

TEACHER'S GUIDE

Catalog No. 34W1023

For use with Student Investigation 34W1123
Class time: two to three 45-minute periods

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

Produced and Distributed by
Ward's Natural Science Establishment, Inc. Rochester, NY • Monterey, CA

Plotting The Shape Of The Ocean Floor

NAGT Crustal Evolution Education Project

Edward G. Stoever, Jr., Project Director

Welcome to the exciting world of current research into the composition history and processes of the earth s crust and the application of this knowledge to man s activities The earth sciences are currently experiencing a dramatic revolution in our understanding of the way in which the earth works CEEP modules are designed to bring into the classroom the methods and results of these continuing investigations The Crustal Evolution Education Project began work in 1974 under the auspices of the National Association of Geology Teachers CEEP materials have been developed by teams of science educators classroom teachers and scientists Prior to publication the materials were field tested by more than 200 teachers and over 12 000 students

Current crustal evolution research is a breaking story that students are living through today

Teachers and students alike have a unique opportunity through CEEP modules to share in the unfolding of these educationally important and exciting advances CEEP modules are designed to provide students with appealing firsthand investigative experiences with concepts which are at or close to the frontiers of scientific inquiry into plate tectonics Furthermore the CEEP modules are designed to be used by teachers with little or no previous background in the modern theories of sea-floor spreading continental drift and plate tectonics

We know that you will enjoy using CEEP modules in your classroom Read on and be prepared to experience a renewed enthusiasm for teaching as you learn more about the living earth in this and other CEEP modules

About CEEP Modules...

Most CEEP modules consist of two booklets a Teacher s Guide and a Student Investigation The Teacher s Guide contains all the information and illustrations in the Student Investigation plus sections printed in color intended only for the teacher as well as answers to the questions that are included in the Student Investigation In some modules there are illustrations that appear only in the Teacher s Guide and these are designated by figure letters instead of the number sequence used in the Student Investigation

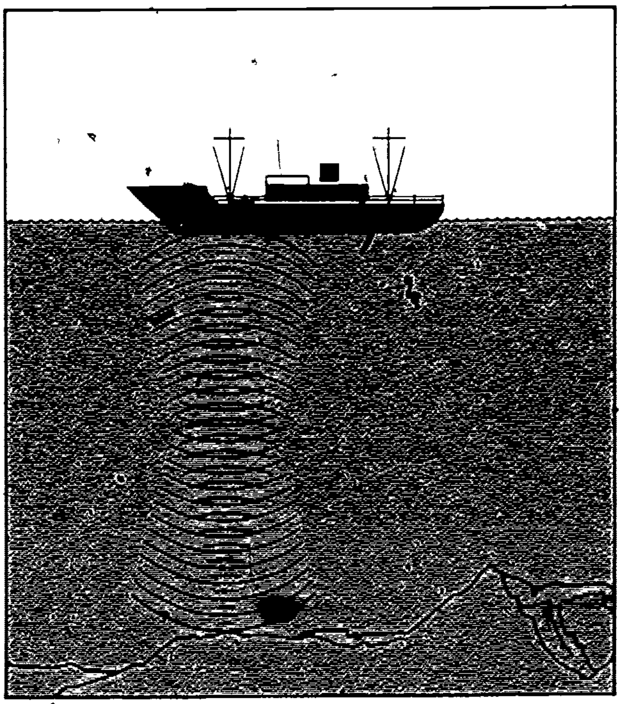
For some modules maps rulers and other common classroom materials are needed, and in varying quantities according to the method of presentation Read over the module before scheduling its use in class and refer to the list of MATERIALS in the module

Each module is individual and self-contained in content but some are divided into two or more parts for convenience The recommended length of time for each module is indicated Some modules require prerequisite knowledge of some aspects of basic earth science this is noted in the Teacher s Guide

The material was prepared with the support of National Science Foundation Grant Nos SED 75-20151 SED 77-08539 and SED 78-25104 However any opinions findings conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of NSF

Plotting The Shape Of The Ocean Floor

INTRODUCTION



An oceanographic research vessel obtains water depth information continuously as the ship criss-crosses an area The depths to the ocean bottom are obtained and recorded by a precision depth recorder, which is an advanced form of **SONAR.** Sound waves are sent away from the hull of the ship, hit an object, are reflected back and recorded. The time to reach the object and return is converted into distance or depth. The plotting machine of the echo sounder produces a **bathymetric profile. Bathymetry** is the measurement of ocean water depth A bathymetric profile shows the shape of the ocean floor beneath the track line of the ship as well as the depth to each point on the profile.

What does an individual profile of the sea floor look like? How can a series of profiles be fitted together to give a limited three-dimensional picture of a small part of the sea floor? What relationship is there between sea-floor features and locations of oceanic earthquakes?

PREREQUISITE STUDENT BACKGROUND

The students should be familiar with latitude and longitude. They should also be familiar with the principle of precision depth recording (echo sounding). In addition, they should have been given instruction in how to construct a bathymetric profile from track line data. They should be informed of only the general nature of ocean basin topography, such as the existence of the continental shelf, slope, and rise; abyssal plain, and the mid-ocean mountain range. Because students will discover the rift valley in the mid-Atlantic mountain range, be sure not to discuss the details of mid-ocean mountain topography prior to use of this module.

OBJECTIVES

After you have completed this activity, you should be able to.

1. Draw a profile of the sea floor using bathymetric data.
2. Identify which topographic elements are similar on many bathymetric profiles across a portion of the sea floor in the North Atlantic Ocean.
3. Describe the relationship between sea-floor topography and earthquake epicenter locations in a part of the North Atlantic Ocean.
4. Compare and contrast the features of the bathymetric profiles with those shown on the National Geographic Society map, *Atlantic Ocean Floor*.
5. Compare the distribution of earthquake epicenters on the bathymetric profiles with those seen on the *World Seismicity Map*.

MATERIALS

For the class:

Atlantic Ocean Floor map, National Geographic Society, Educational Services, Department 79, Washington, D.C. 20036.

World Seismicity Map, U.S. Geological Survey, 1200 S. Eads Street, Arlington, VA 22202.

For each student:

- Pencil with eraser
- Graph paper, heavier lines every tenth line
- Scissors
- 15 cm ruler or straight edge
- Red marking pen
- Construction paper, 2 or 3 sheets
- Liquid glue, or tape with adhesive on both sides
- Cellophane (or masking) tape
- Small wooden blocks (optional)

BACKGROUND INFORMATION

The data given on the track line chart (Worksheet) were obtained by the Research Vessel Vema, from continuous echo-sounding along track lines roughly at right angles to the mid-ocean ridge. The depths given on the track chart have been selected to give the students representative depth points with which to draw a bathymetric profile. Many of the points are as much as 4 km apart, and therefore, the chart does *not* show all of the topographic details known to oceanographers.

These are the only reliable track line data that R.V. Vema has obtained of areas at right angles to the trend of the mid-ocean ridge over the last decade or so. The topography between the track lines is largely uncharted. However, track lines from other research ships confirm the overall pattern of topography revealed by the Vema soundings.

The track lines are not at exact right angles to the mid-ocean ridge line. Some of the deeper depressions that the students may detect on the sides of the profile could be caused by fracture zones which would be generally parallel to the track lines. But additional data would be needed to locate the fracture zones. Therefore, a discussion of fracture zones might follow student completion of profile 1-1 as described in EXTENSION 1.

The relief of the study area is caused by volcanic, tectonic (earth-building) and sedimentary processes. The mid-ocean ridge is made up largely of underwater central volcanoes (seamounts) which rise to within 1700 m of the sea surface in this area. The volcanoes are built from basaltic lava which oozes out into the water through cracks in the sea floor. Because it is chilled swiftly, the lava forms pillow structures made of fine-grained basaltic rock.

The ridge has a central valley along its length, the base of which is about 2000 m below the adjacent lines of seamounts. The valley in the study area, which is up to 20 km wide, is formed by the relative downsliding of a linear strip of oceanic lithosphere. Such valleys are usually called rift valleys.

In Iceland, where this valley can be observed on land, the countless open fissures testify to the stretching of the earth's crust at right angles to the ridge and rift valley. This confirms the sea-floor spreading hypothesis, which assumes that the ocean is widening at right angles to its midline. The fissures are often filled with upwelling magma, and sheet-like masses (dikes) of medium-grained basic rock (dolerite) are emplaced. The fissures also feed central volcanoes. At the margins of the mid-ocean ridge, hundreds of kilometers from the midline, the topography is diminished somewhat by the deposition of fine-grained deep sea sediments in the areas between the seamounts. The lessening of the original relief by sedimentation has little effect in the study area because the rocks are so young that sediment has had little time to accumulate.

The positions of the earthquakes plotted on the chart (Worksheet) represent all the data available in this area for the period 1966-76. In some cases the presence of an earthquake was determined after examining records of earthquake shocks received by over 100 seismological stations scattered through all parts of the world. Since about 1966, the location of an earthquake can be determined within one tenth of a degree of latitude (roughly 10 km) or less. After the students have plotted their profiles, they will be able to see a close relationship between the positions of the earthquake epicenters and the central rift valley or its margins. Their presence indicates that active earth movements, associated both with volcanism and the stretching of the earth's crust, are taking place along this zone. A few of the earthquakes lie away from the mid-ocean line. These are probably associated with fracture zones trending at right angles to the mid-ocean ridge line.

The age of the seamount volcanoes generally increases in direct proportion to their distance from the mid-ocean ridge line. The oldest volcanic rocks, lying beneath sediments near the margins of the North Atlantic, are at least of Cretaceous age. Therefore, the underlying volcanic rocks must be this same age or older.

In general, the elevated relief along the mid-ocean ridge was caused by the heating and expansion of the columns of rock lying beneath the ridge. As the ridge area is augmented by volcanic extrusions and dikes, and as it widens and moves laterally, the ocean widens from its midline outwards. As the rocks move laterally, they cool and contract and there is a progressive (exponential) decrease in height towards the margins.

SUGGESTED APPROACH

During the first few minutes of class, review the fundamentals of latitude and longitude. Describe the action of SONAR, and how these data are collected. Mention that the sea is one of the last "reachable" frontiers, just beginning to be explored.

The students should be told that the Worksheet has track lines, or "paths" the ships followed in crossing the ocean. The numbers which appear along the track line are depths below sea level, in meters, to the ocean floor.

Do not give away the thrust of the activity by discussing or illustrating the lines of seamounts on either side of the rift valley at the crest of the Mid-Atlantic Ridge, or the fracture zones, at right angles to the ridge crest, which may be present in the study area.

Assign seven students to each team. Individuals within the team will construct one or more bathymetric profiles numbered 2-2 through 10-10. For purposes of efficiency assign one student to each of the profiles numbered 2-2 through 6-6. Assign one student to construct profiles 7-7 and 8-8 and one student to construct profiles 9-9 and 10-10. Profile 1-1 reveals a phenomenon not present in the other profiles; it is treated in the EXTENSIONS section.

If one team has less than seven students, profiles 6-6, 8-8 or 9-9 can be dropped from the group task.

One track-line chart (Worksheet) should be designated as the team chart on which the completed bathymetric profiles will be assembled.

If conditions allow, you might make a bathymetric profile construction and assembly into a game situation in which the fastest and most accurate team receives additional praise or an award.

Assigning the students to plot their bathymetric profiles at home is well worth considering. They could work through PROCEDURE steps 10-12 as homework.

PROCEDURE

In this activity, each student constructs a bathymetric profile from data recorded on a track chart. The profiles are then assembled on the chart to allow each team of students to "view" and interpret the ocean floor topography.

Key words: SONAR, bathymetric profile, bathymetry

Time required: two to three 45-minute periods

Materials. graph paper, pencil, scissors, ruler, red marking pen, liquid glue or tape with adhesive on both sides, construction paper, and wood blocks (optional)

1. To prepare a depth scale for the bathymetric profile, start by writing the number, "1000 m", at several places along the top, ruled line of your graph paper

2. On the next thick, ruled line write the number, "2000 m", at several places along the line

3. In the same way label 3000, 4000 and 5000 m on the third, fourth, and fifth thick, ruled lines on the graph paper

4. Cut the graph paper along the 1000 m and 5000 m depth lines.

5. Position the 1000 m line of the graph paper along the track line on the Worksheet assigned by your teacher. If you have been assigned track line 2-2, 3-3, 4-4 or 5-5, start your profile at the right end of the track line. As you move to the left, stop the profile plot at the left edge of your graph paper.

6. Based on your previous practice in plotting bathymetric profiles, transfer the depth information from your track line to the strip of graph paper.

7. Draw the bathymetric profile by connecting the data in sequence from the first point, to the second, to the third, and so on. Use a pencil and ruler for connecting the data points.

8. Earthquake epicenters are shown on the Worksheet by large, five-pointed stars. Find any earthquake epicenters that lie directly on your track line. Use a marking pen to make a large dot on the bathymetric profile at the position of an earthquake epicenter.

9. Find any earthquake epicenters that lie nearer your track line than to the track lines to the north or south. Draw a line on the Worksheet, at about right angles to your track line, through one of the nearby earthquake epicenters. As before, make a large dot on the bathymetric profile at the place where this earthquake epicenter line hits your track line

Repeat the procedure for each earthquake epicenter near your track line

7

10. Use liquid glue, or tape with adhesive on both sides, to attach the graph paper strip to a similar size strip of construction paper.

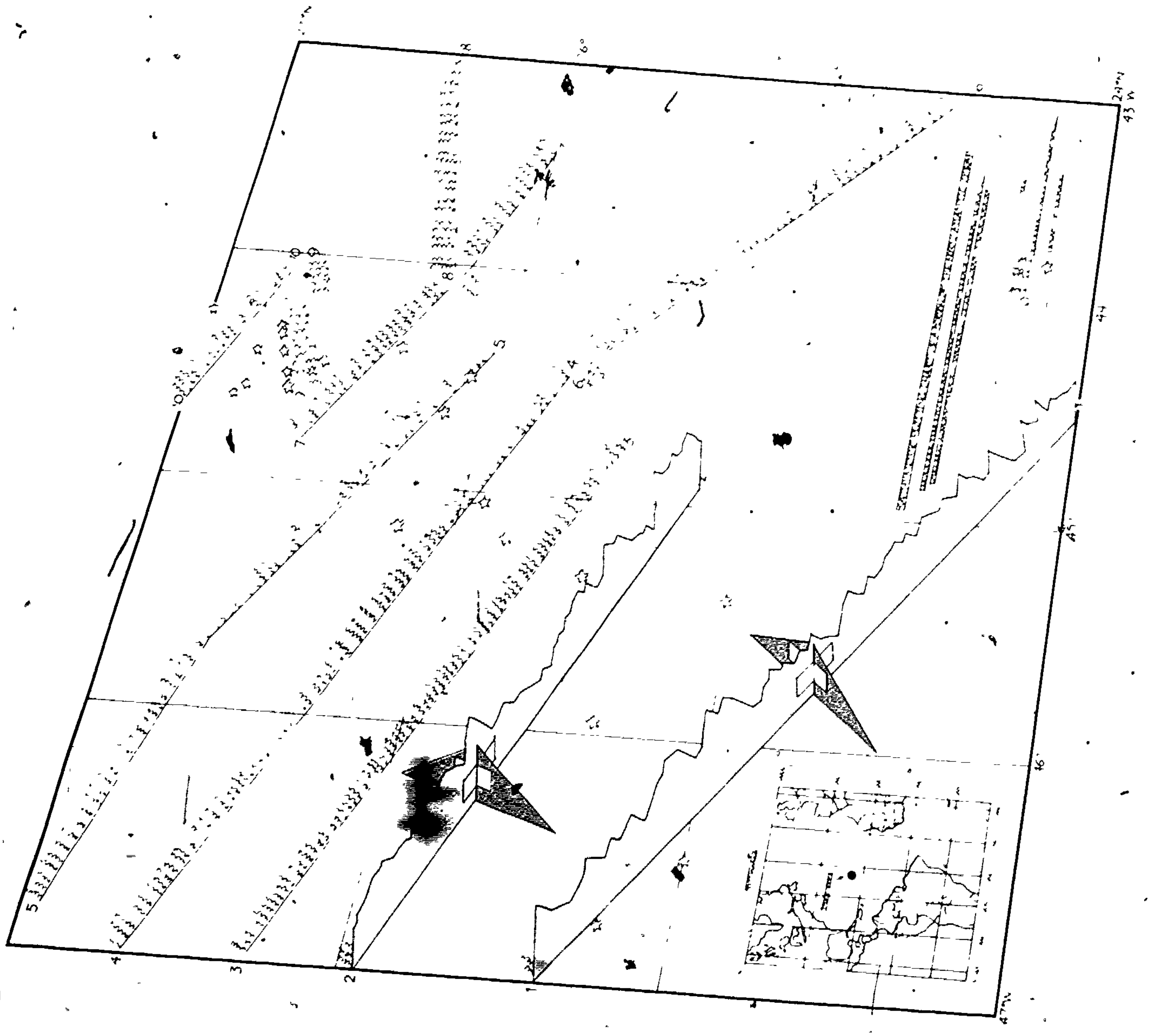
11. Use scissors to cut along the bathymetric profile line. Cut off any excess paper along the 5000 m line and the ends of the profile line. In the space below, write a sentence or two that describes the bathymetric profile cut-out.

The sea floor shows an irregular series of narrow peaks and valleys. See Answer Sheet.

12. Cut two small right triangles, about 3 cm on each side, from the excess construction paper. Tape one to each side of the profile cut-out so it can stand up. See Figure 1.

If small blocks of wood are available, the students can fasten these to the bottoms of their profiles with thumb tacks in such a way that they will stand up.

13. Place your profile cut-out in its proper position along the Worksheet being used for your student team. Follow the teacher's instructions on what to do until all profile cut-outs have been placed on the Worksheet. See Figure 1.



1. Diagram showing profiles in upright position.

14. Bend down so that your sight line is just above the profile cut-outs as you look across them. Profile cut-out 2-2 should be closest to you and profile cut-out 10-10 farthest away.

By moving your head up and down or side to side, try to locate similar mountains or valleys that appear at roughly the same position on three or more profiles.

15. Study the map, *Atlantic Ocean Floor*. Locate the latitude and longitude of your study area. What is the name of the topographic feature shown by your profiles?

Mid-Atlantic Ridge

16. How does the topography shown on the map compare with the topography shown by your profiles?

The profiles show a deep valley surrounded by seamounts on either side. The map shows that this topography is found along the entire length of the Mid-Atlantic Ridge.

17. Locate the study area on the *World Seismicity Map*. By comparing this map with the map, *Atlantic Ocean Floor*, determine the general relationship between the location of earthquake epicenters and sea-floor topography. Write a sentence in the space below which describes this relationship.

Earthquake epicenters are closely related to the presence of the deep central valley and nearby seamounts.

18. Study the depth of earthquake foci (origin points) on the *World Seismicity Map*. At what depth zone are earthquake foci found in the study area and along the entire mid-ocean ridge system?

0-70 km

SUMMARY QUESTIONS

1. Describe the kinds of topography found in the middle of the North Atlantic Ocean

Seamounts, narrow valleys and a rift valley are found along the midline of the Mid-Atlantic Ridge. See Answer Sheet.

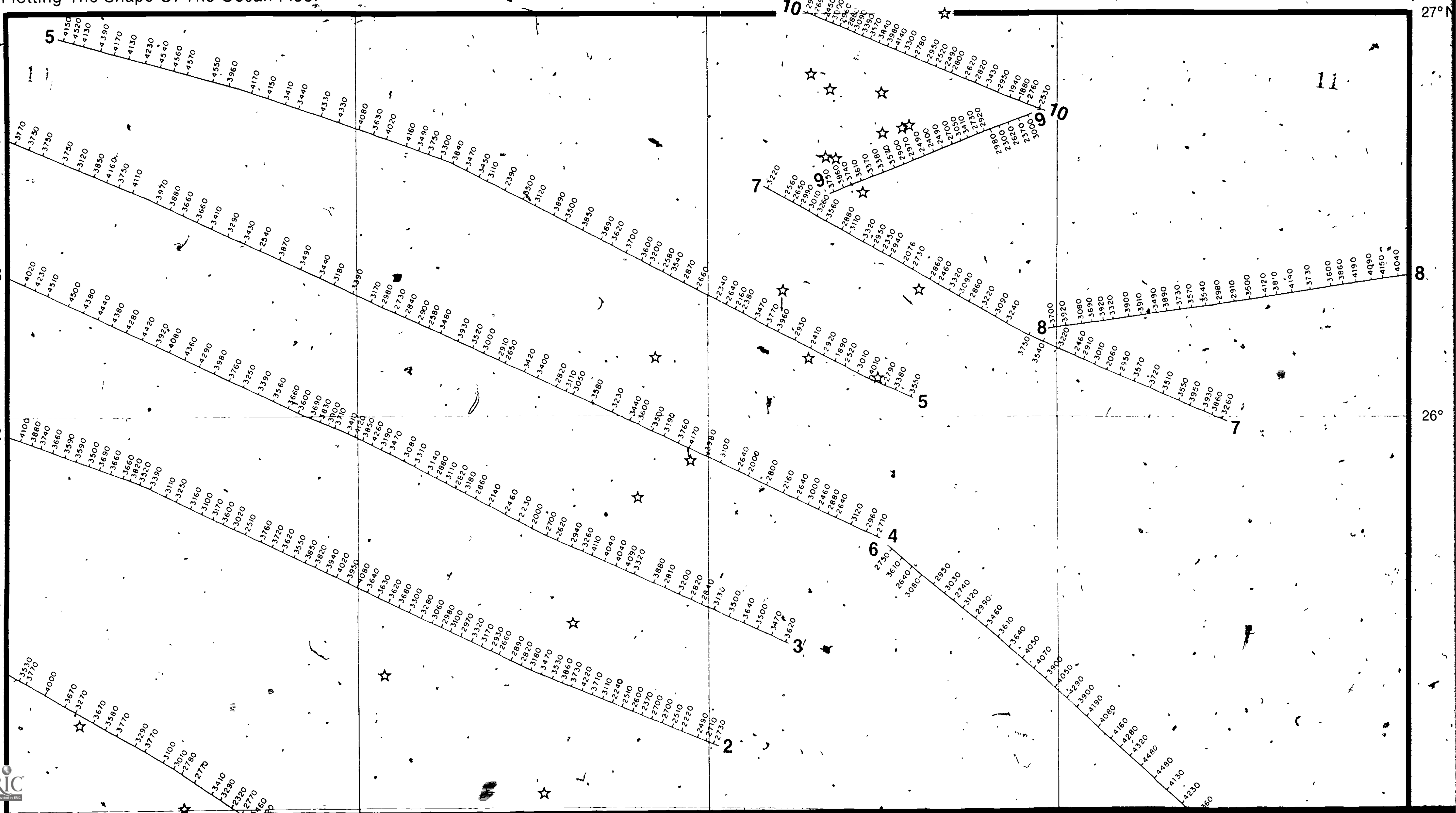
2. Describe the topography (question 1) tracing from west to east across the Mid-Atlantic Ridge

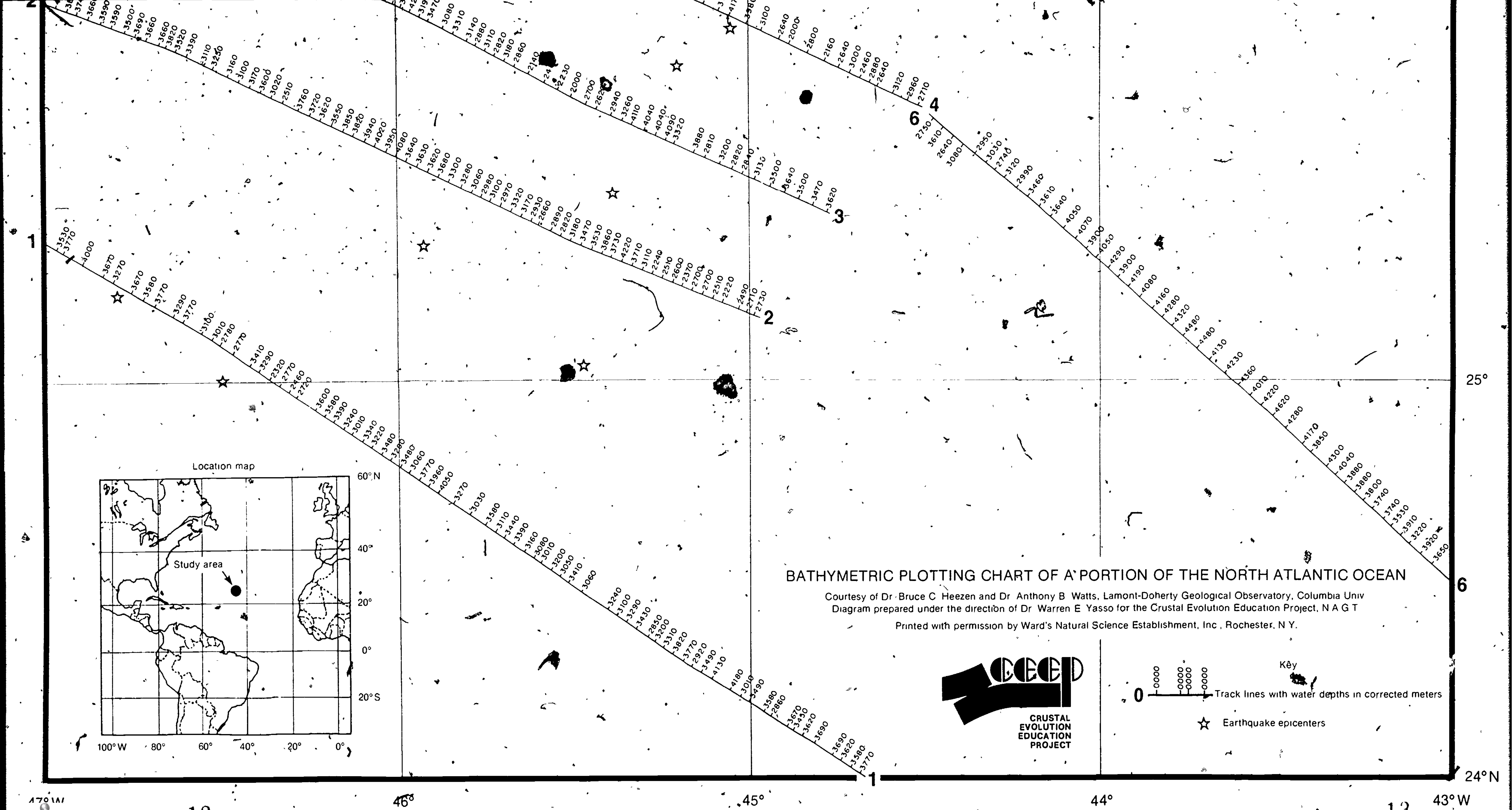
From west to east, seamounts rise in elevation toward the midline of the Mid-Atlantic Ridge. A deep depression is formed by the rift valley. Tall seamounts flank the rift valley on the east and decrease in height away from the center-line of the Mid-Atlantic Ridge.

3. What is the relationship between earthquake epicenter locations and the topography of the middle North Atlantic Ocean?

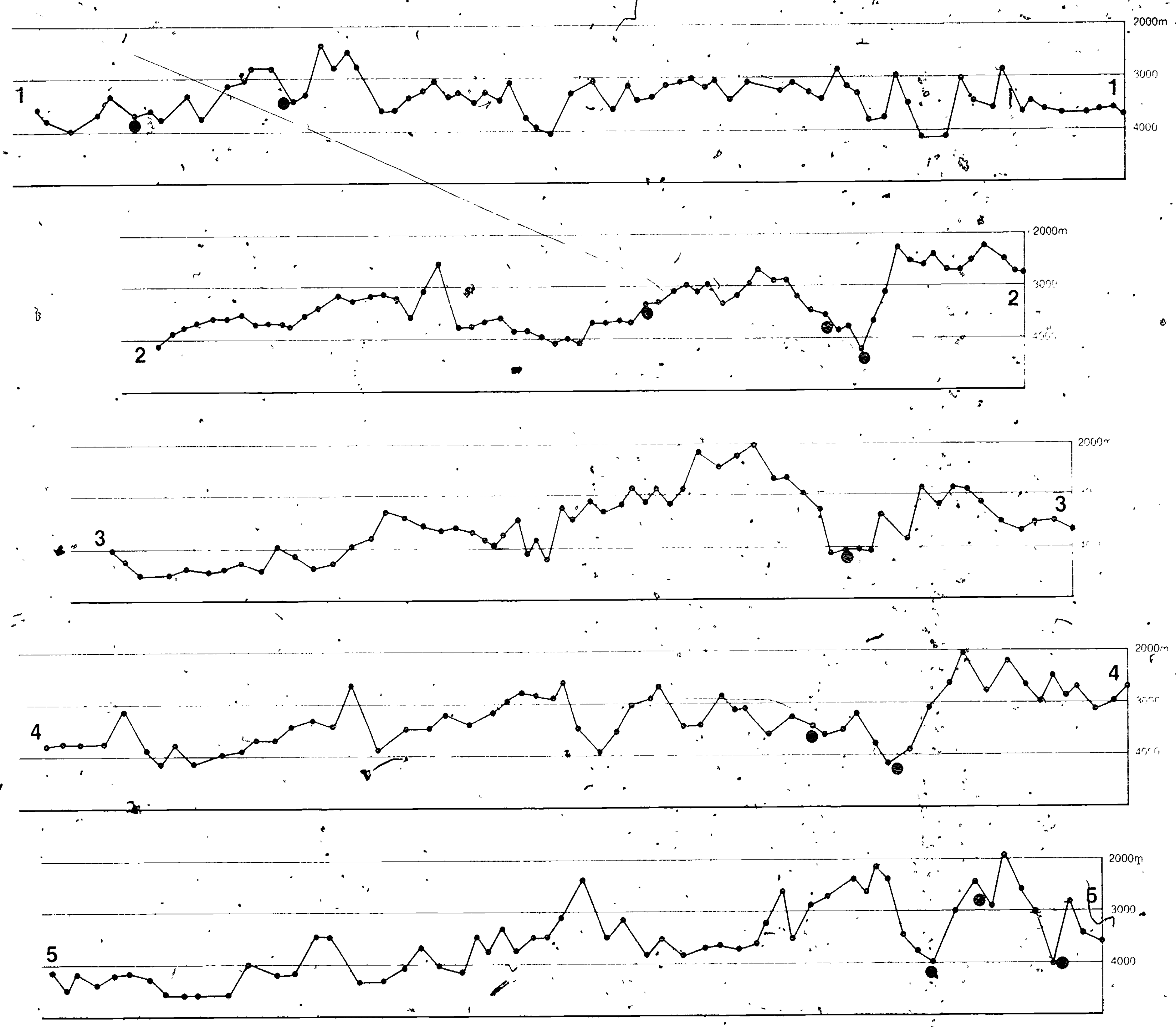
The epicenters generally lie in or near the rift valley in the middle of the North Atlantic Ocean.

Plotting The Shape Of The Ocean Floor

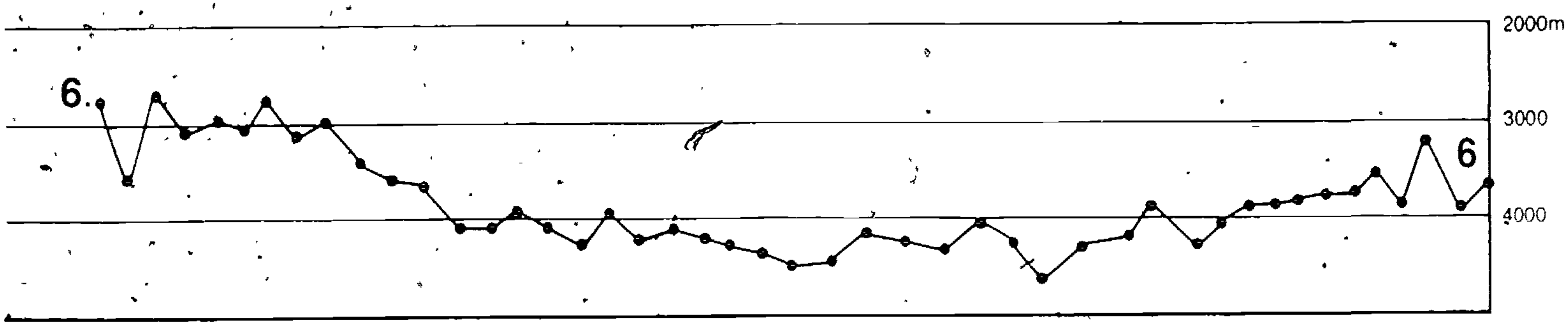


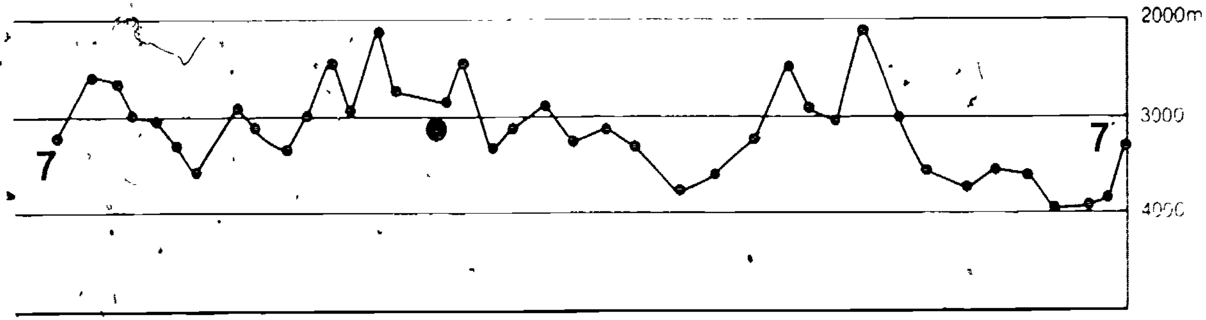

BATHYMETRIC PLOTTING CHART OF A PORTION OF THE NORTH ATLANTIC OCEAN
Courtesy of Dr Bruce C Heezen and Dr Anthony B Watts, Lamont-Doherty Geological Observatory, Columbia Univ
Diagram prepared under the direction of Dr Warren E Yasso for the Crustal Evolution Education Project, N A G T
Printed with permission by Ward's Natural Science Establishment, Inc , Rochester, N Y.
CRUSTAL EVOLUTION EDUCATION PROJECT
Key
Track lines with water depths in corrected meters
Earthquake epicenters
Location map
Study area
60° N
40°
20°
0°
20° S
100° W
80°
60°
40°
20°
0°
25°
24° N
46°
45°
44°
43° W

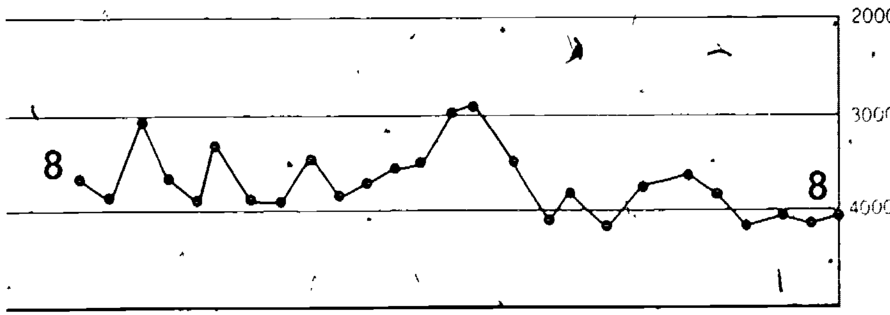
ksheet

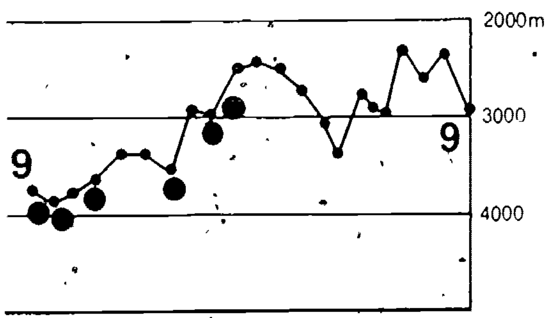


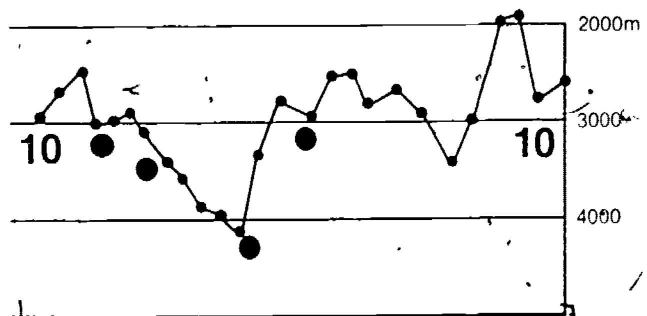
Answer Sheet


6.
6
2000m
3000
4000


7
7
2000m
3000
4000


8
8
2000m
3000
4000


9
9
2000m
3000
4000


10
10
2000m
3000
4000

EXTENSIONS

1. The first student who finishes the bathymetric cut-out can be assigned to prepare the cut-out for track line 1-1. When placed on the track line chart, the cut-out will reveal a poorly defined central valley and this valley appears in a more westerly position. The shift in position may be related to a fracture zone lying between profiles 1-1 and 2-2. Students may need to investigate fracture zones and transform faults before they can understand the significance of such phenomena in the trend line of the mid-ocean ridge. The fracture zones appear clearly on the map.

Construct a profile cut-out for track line 1-1. How does the pattern of topography on this profile compare with the other profiles? If there are any differences, try to explain them from further study of the map, *Atlantic Ocean Floor.*

2. In this EXTENSION students are asked to express their literary or artistic feelings about the underwater landscape of this area, which has many times the relief and grandeur of the Grand Canyon.

Write a paragraph, or poem, or sketch a picture in your booklet that tells or shows what it might be like to stand on top of the highest mountain or the deepest valley shown on your profiles. For comparison, you might want to read how John Wesley Powell felt about looking up from the floor of the Colorado River valley in the Grand Canyon. Powell was the first scientist to organize a geological exploration of the Grand Canyon region.

Powell described the experience in these words:

> "We are three-quarters of a mile in the depths of the earth and the great river shrinks into insignificance, as it dashes its angry waves against the walls and cliffs, that rise to the world above; they are but puny ripples, and we but pigmies, running up and down the sands, or lost among the boulders.
>
> "We have an unknown distance yet to run, an unknown river yet to explore. What falls there are, we know not; what rocks beset the channels, we know not, what walls rise over the river, we know not."

- From *John Wesley Powell's* exploration of the Colorado River, U.S Geological Survey. INF 74-19

REFERENCES

Brandwein, P.F., and others, 1975, *Matter: an earth science* (3rd ed.). New York, Harcourt Brace Jovanovich.

Heezen, B.C., 1960, Submarine topography. *McGraw Hill Encyclopedia of Science and Technology*, p. 216-223.

Heezen, B.C., 1960, The rift in the ocean floor. *Scientific American*, v. 203, no. 4 (Oct.), p. 98-110.

Heezen, B.C., Tharp, M. and Ewing, M., 1959, *The floors of the ocean. 1. The North Atlantic.* The Geological Society of America special paper 65, 122 p.

Heirtzler, J.R. and Bryan, W.B., 1975, The floor of the Mid-Atlantic Rift. *Scientific American*, v. 233, no. 2 (Aug.), p. 78-90.

NAGT Crustal Evolution Education Project Modules

CEEP Modules are listed here in alphabetical order. Each Module is designed for use in the number of class periods indicated. For suggested sequences of CEEP Modules to cover specific topics and for correlation of CEEP Modules to standard earth science textbooks, consult Ward's descriptive literature on CEEP. The Catalog Numbers shown here refer to the CLASS PACK of each Module consisting of a Teacher's Guide and 30 copies of the Student Investigation. See Ward's descriptive literature for alternate order quantities.

CEEP Module	Class Periods	CLASS PACK Catalog No.
• A Sea-floor Mystery: Mapping Polarity Reversals	3	34 W 1201
• Continents And Ocean Basins: Floaters And Sinkers	3-5	34 W 1202
• Crustal Movement: A Major Force In Evolution	2-3	34 W 1203
• Deep Sea Trenches And Radioactive Waste	1	34 W 1204
• Drifting Continents And Magnetic Fields	3	34 W 1205
• Drifting Continents And Wandering Poles	4	34 W 1206
• Earthquakes And Plate Boundaries	2	34 W 1207
• Fossils As Clues To Ancient Continents	2-3	34 W 1208
• Hot Spots In The Earth's Crust	3	34 W 1209
• How Do Continents Split Apart?	2	34 W 1210
• How Do Scientists Decide Which Is The Better Theory?	2	34 W 1211
• How Does Heat Flow Vary In The Ocean Floor?	2	34 W 1212
• How Fast Is The Ocean Floor Moving?	2-3	34 W 1213
• Iceland: The Case Of The Splitting Personality	3	34 W 1214
• Imaginary Continents: A Geological Puzzle	2	34 W 1215
• Introduction To Lithospheric Plate Boundaries	1-2	34 W 1216
• Lithospheric Plates And Ocean Basin Topography	2	34 W 1217
• Locating Active Plate Boundaries By Earthquake Data	2-3	34 W 1218
• Measuring Continental Drift: The Laser Ranging Experiment	2	34 W 1219
• Microfossils, Sediments And Sea-floor Spreading	4	34 W 1220
• Movement Of The Pacific Ocean Floor	2	34 W 1221
• Plate Boundaries And Earthquake Predictions	2	34 W 1222
• Plotting The Shape Of The Ocean Floor	2-3	34 W 1223
• Quake Estate (board game)	3	34 W 1224
• Spreading Sea Floors And Fractured Ridges	2	34 W 1225
• The Rise And Fall Of The Bering Land Bridge	2	34 W 1227
• Tropics In Antarctica?	2	34 W 1228
• Volcanoes: Where And Why?	2	34 W 1229
• What Happens When Continents Collide?	2	34 W 1230
• When A Piece Of A Continent Breaks Off	2	34 W 1231
• Which Way Is North?	3	34 W 1232
• Why Does Sea Level Change?	2-3	34 W 1233

WARD'S

Ward's Natural Science Establishment, Inc.

P.O. Box 1712, Rochester, New York 14603 • P.O. Box 1749, Monterey, California 93940

MODULE NO. NY11 3-1

0-89873-044-9

Printed in U.S.A.

CRUSTAL EVOLUTION EDUCATION PROJECT

NAME DATE

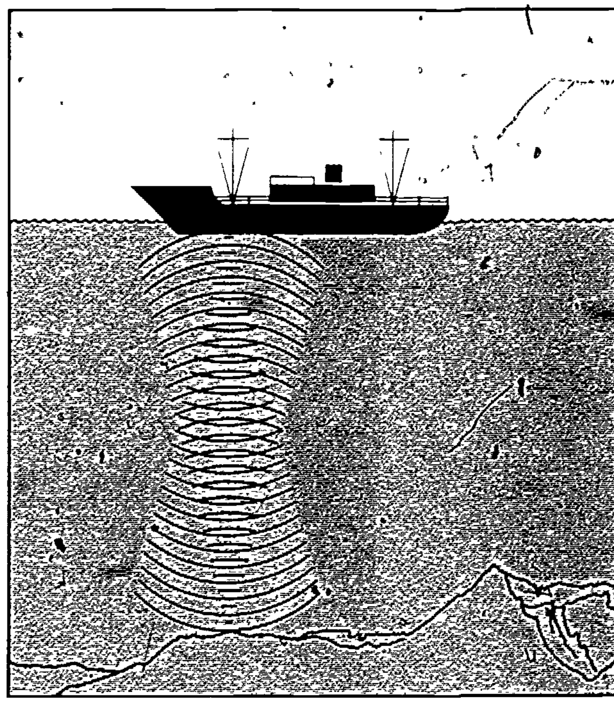
Student Investigation

Catalog No 34W1123

Plotting The Shape Of The Ocean Floor

INTRODUCTION

An oceanographic research vessel obtains water depth information continuously as the ship criss-crosses an area The depths to the ocean bottom are obtained and recorded by a precision depth recorder, which is an advanced form of **SONAR.** Sound waves are sent away from the hull of the ship, hit an object, are reflected back and recorded The time to reach the object and return, is converted into distance or depth The plotting machine of the echo sounder produces a **bathymetric profile. Bathymetry** is the measurement of ocean water depth A bathymetric profile shows the shape of the ocean floor beneath the track line of the ship as well as the depth to each point on the profile



What does an individual profile of the sea floor look like? How can a series of profiles be fitted together to give a limited three-dimensional picture of a small part of the sea floor? What relationship is there between sea-floor features and locations of oceanic earthquakes?

OBJECTIVES

After you have completed this activity, you should be able to

1. Draw a profile of the sea floor using bathymetric data
2. Identify which topographic elements are similar on many bathymetric profiles across a portion of the sea floor in the North Atlantic Ocean
3. Describe the relationship between sea-floor topography and earthquake epicenter locations in a part of the North Atlantic Ocean.
4. Compare and contrast the features of the bathymetric profiles with those shown on the National Geographic Society map, *Atlantic Ocean Floor.*
5. Compare the distribution of earthquake epicenters on the bathymetric profiles with those seen on the *World Seismicity Map.*

PROCEDURE

Materials. graph paper, pencil, scissors, ruler, red marking pen, liquid glue or tape with adhesive on both sides, construction paper, and wood blocks (optional)

1. To prepare a depth scale for the bathymetric profile, start by writing the number, "1000 m", at several places along the top, ruled line of your graph paper

2. On the next thick, ruled line write the number, "2000 m", at several places along the line

3. In the same way label 3000, 4000 and 5000 m on the third, fourth, and fifth thick, ruled lines on the graph paper

4. Cut the graph paper along the 1000 m and 5000 m depth lines

5. Position the 1000 m line of the graph paper along the track line on the Worksheet assigned by your teacher If you have been assigned track line 2-2, 3-3, 4-4 or 5-5, start your profile at the right end of the track line. As you move to the left, stop the profile plot at the left edge of your graph paper.

6. Based on your previous practice in plotting bathymetric profiles, transfer the depth information from your track line to the strip of graph paper

7. Draw the bathymetric profile by connecting the data in sequence from the first point, to the second, to the third, and so on Use a pencil and ruler for connecting the data points

8. Earthquake epicenters are shown on the Worksheet by large, five-pointed stars. Find any earthquake epicenters that lie directly on your track line. Use a marking pen to make a large dot on the bathymetric profile at the position of an earthquake epicenter.

9. Find any earthquake epicenters that lie nearer your track line than to the track lines to the north or south. Draw a line on the Worksheet, at about right angles to your track line, through one of the nearby earthquake epicenters. As before, make a large dot on the bathymetric profile at the place where this earthquake epicenter line hits your track line

Repeat the procedure for each earthquake epicenter near your track line.

10. Use liquid glue, or tape with adhesive on both sides, to attach the graph paper strip to a similar size strip of construction paper.

11. Use scissors to cut along the bathymetric profile line. Cut off any excess paper along the 5000 m line and the ends of the profile line In the space below, write a sentence or two that describes the bathymetric profile cut-out

12. Cut two small right triangles, about 3 cm on each side, from the excess construction paper Tape one to each side of the profile cut-out so it can stand up. See Figure 1

13. Place your profile cut-out in its proper position along the Worksheet being used for your student team Follow the teacher's instructions on what to do until all profile cut-outs have been placed on the Worksheet See Figure 1

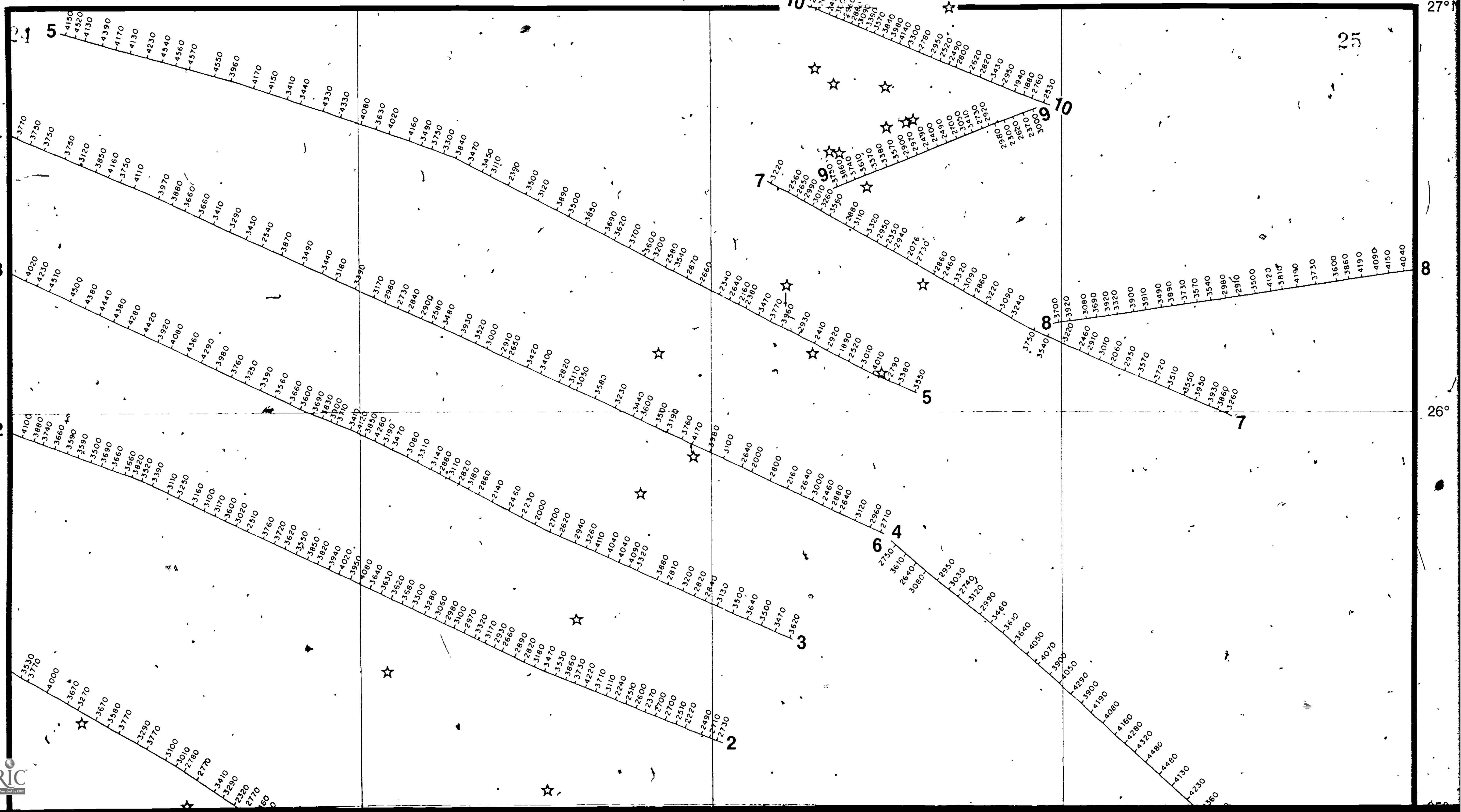
14. Bend down so that your sight line is just above the profile cut-outs as you look across them Profile cut-out 2-2 should be closest to you and profile cut-out 10-10 farthest away.

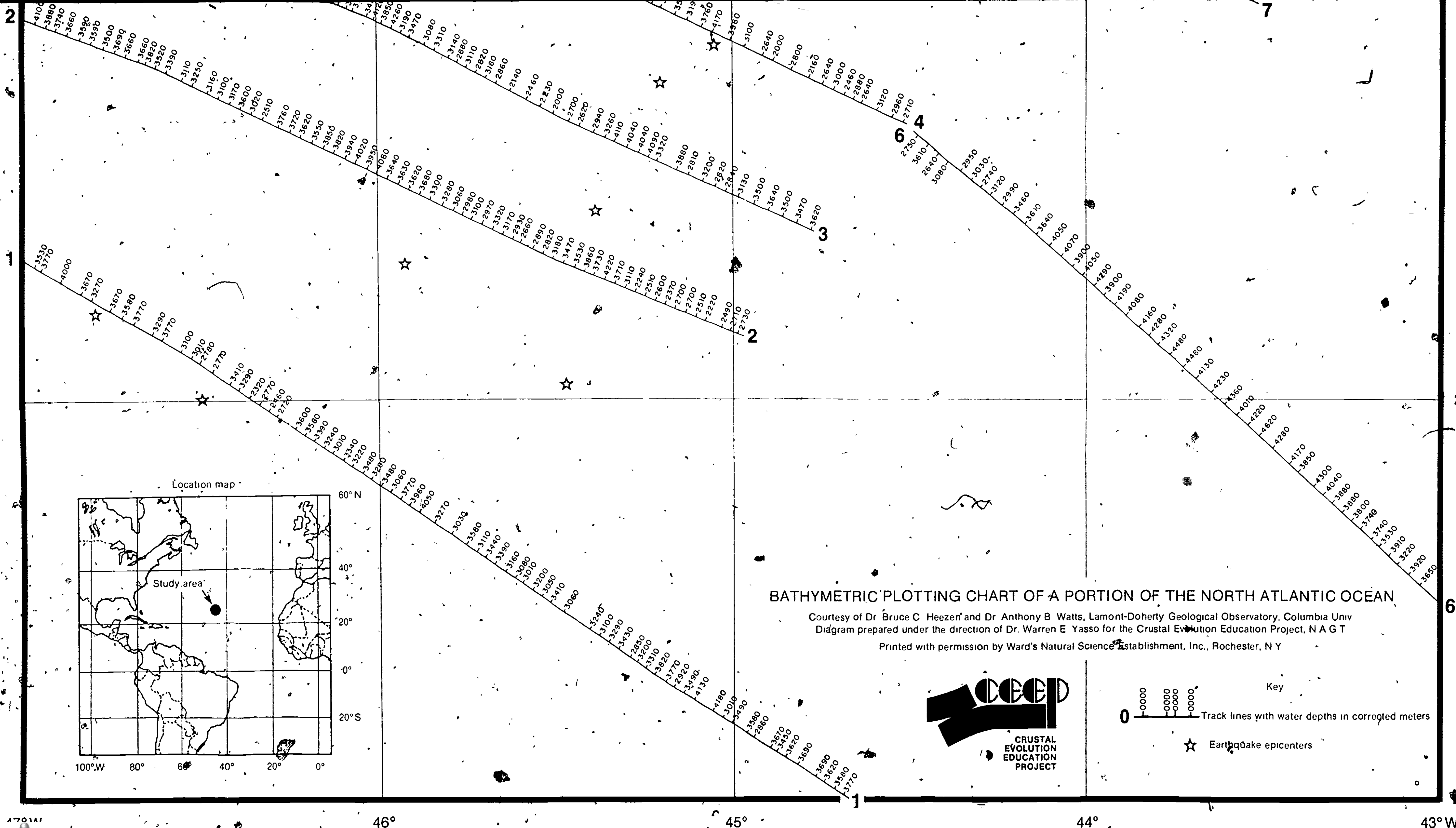
By moving your head up and down or side to side, try to locate similar mountains or valleys that appear at roughly the same position on three or more profiles

15. Study the map, *Atlantic Ocean Floor.* Locate the latitude and longitude of your study area What is the name of the topographic feature shown by your profiles?

16. How does the topography shown on the map compare with the topography shown by your profiles?

Plotting The Shape Of The Ocean Floor




BATHYMETRIC PLOTTING CHART OF A PORTION OF THE NORTH ATLANTIC OCEAN
Courtesy of Dr Bruce C Heezen and Dr Anthony B Watts, Lamont-Doherty Geological Observatory, Columbia Univ
Diagram prepared under the direction of Dr. Warren E Yasso for the Crustal Evolution Education Project, N A G T
Printed with permission by Ward's Natural Science Establishment, Inc., Rochester, N Y
CRUSTAL EVOLUTION EDUCATION PROJECT
Key
Track lines with water depths in corrected meters
Earthquake epicenters
Location map
Study area
60° N
40°
20°
0°
20° S
100° W
80°
60°
40°
20°
0°
25°
24° N
46°
45°
44°
43° W

17. Locate the study area on the *World Seismicity Map*. By comparing this map with the map, *Atlantic Ocean Floor*, determine the general relationship between the location of earthquake epicenters and sea-floor topography. Write a sentence in the space below which describes this relationship

18. Study the depth of earthquake foci (origin points) on the *World Seismicity Map*. At what depth zone are earthquake foci found in the study area and along the entire mid-ocean ridge system?

SUMMARY QUESTIONS

1. Describe the kinds of topography found in the middle of the North Atlantic Ocean

2. Describe the topography (question 1) tracing from west to east across the Mid-Atlantic Ridge

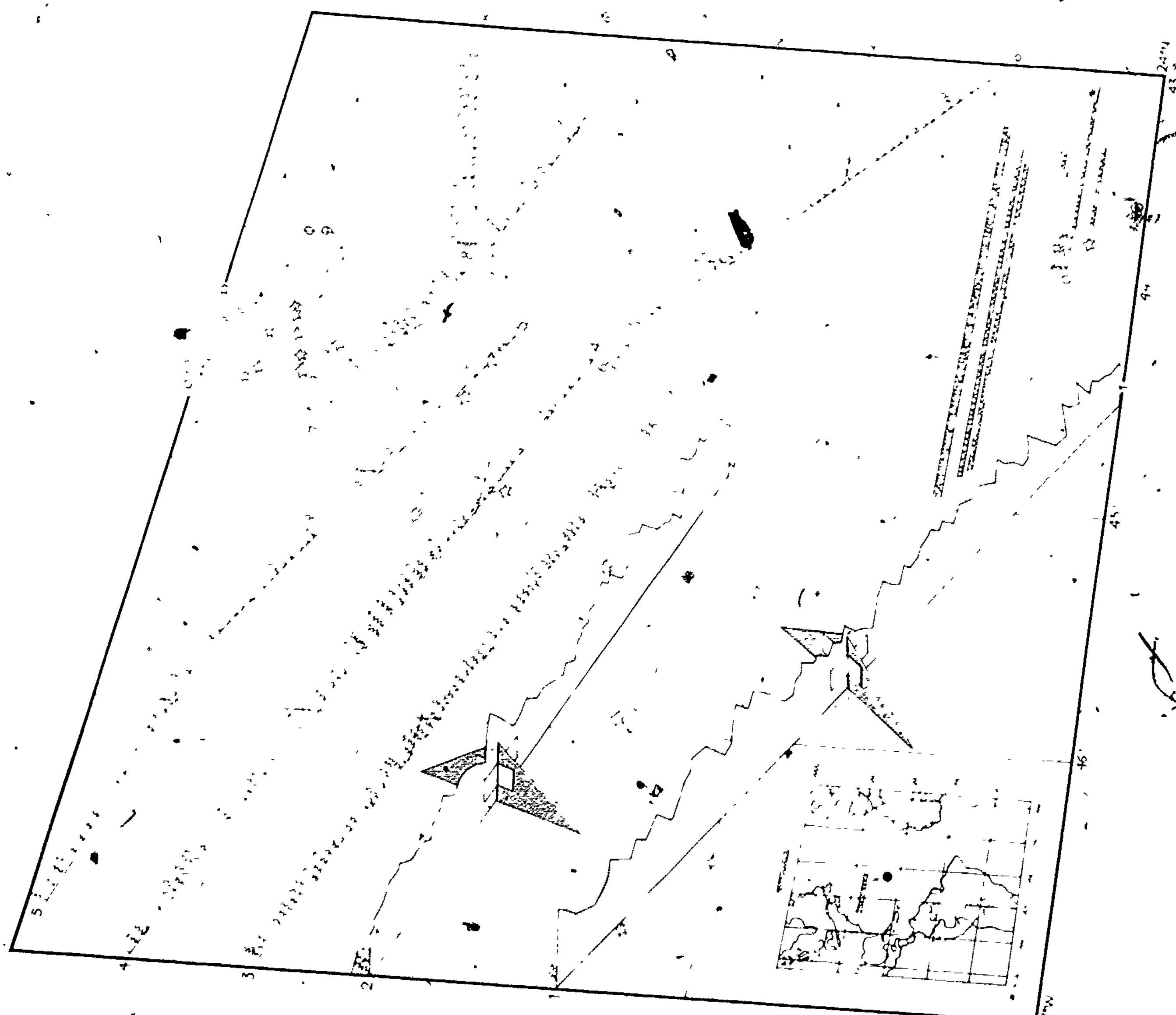


Figure 1. Diagram showing profiles in upright position.

3. What is the relationship between earthquake epicenter locations and the topography of the middle North Atlantic Ocean?

EXTENSIONS

1. Construct a profile cut-out for track line 1-1 How does the pattern of topography on this profile compare with the other profiles? If there are any differences, try to explain them from further study of the map, *Atlantic Ocean Floor*

2. Write a paragraph, or poem, or sketch a picture in your booklet that tells or shows what it might be like to stand on top of the highest mountain or the deepest valley shown on your profiles For comparison, you might want to read how John Wesley Powell felt about looking up from the floor of the Colorado River valley in the Grand Canyon Powell was the first scientist to organize a geological exploration of the Grand Canyon region

Powell described the experience in these words

"We are three-quarters of a mile in the depths of the earth and the great river shrinks into insignificance, as it dashes its angry waves against the walls and cliffs, that rise to the world above, they are but puny ripples, and we but pigmies, running up and down the sands, or lost among the boulders.

"We have an unknown distance yet to run, an unknown river yet to explore What falls there are, we know not, what rocks beset the channels, we know not, what walls rise over the river, we know not"

From *John Wesley Powell's* exploration of the Colorado River, U S Geological Survey. INF 74-19

REFERENCES

Brandwein, P F , and others,1975, *Matter. an earth science* (3rd ed) New York, Harcourt Brace Jovanovich.

Heezen, B C , 1960, Submarine topography *McGraw Hill Encyclopedia of Science and Technology*. p 216-223

Heezen, B C , 1960, The rift in the ocean floor *Scientific American*, v 203, no. 4 (Oct), p 98-110.

Heirtzler, J R and Bryan, W B., 1975, The floor of the Mid-Atlantic Rift. *Scientific American*, v 233, no 2 (Aug), p 78-90

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

The material was prepared with the support of National Science Foundation Grant Nos SED 75-20151 SED 77-08539 and SED 78-25104 However any opinions findings conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of NSF

WARD'S

Ward's Natural Science Establishment, Inc. Rochester, NY • Monterey, CA

ISBN 0-89873-045-7
Printed in U S A.